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COMPARING OBJECTIVE MEASURES AND PERCEPTIONS OF COGNITIVE LEARNING IN AN ERP SIMULATION GAME: A RESEARCH NOTE

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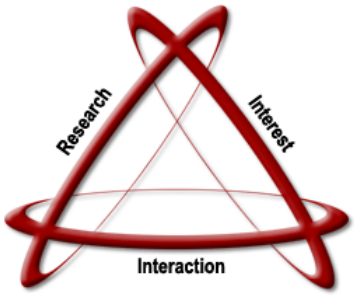

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Comparing Objective Measures and Perceptions of Cognitive Learning in an ERP Simulation Game: A Research Note

Working Paper

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Abstract

Enterprise Resource Planning (ERP) systems have had a significant impact on business organizations (Liang, et al., 2007). These large systems offer opportunities for companies regarding the integration and functionality of information technology systems; in effect, companies can realize a competitive advantage that is necessary in today's global companies. However, effective training for the incorporation and use of these large scale systems is both difficult and challenging; improved strategies for effective training include the use business simulations. The question of the effectiveness of training remains – "how do we measure learning?" Anderson and Lawton (2009) in a recent Simulation & Gaming article "Business Simulations and Cognitive Learning" focus on research associated with the assessment of cognitive learning in business simulations. They indicate that little progress has occurred in objectively assessing cognitive learning in simulations and call for research that might help determine whether simulations accomplish what they purport to achieve in terms of participant learning. In this research note, objective measures of learning are presented. The results of objective measures of learning are compared to those of self-assessed perception of learning in the context of an Enterprise Resource Planning (ERP) business simulation game. Based on the comparisons of learning measures, self-assessed measure results were not different from those of objective measures; moreover, learning did occur.

Keywords – ERP (enterprise resource planning), learning assessment, measures

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Introduction

Anderson and Lawton (2009), in their recent *Simulation & Gaming* article "Business Simulations and Cognitive Learning," focus on research associated with the assessment of cognitive learning in business simulations. They indicate that little progress has occurred in objectively assessing cognitive learning in simulations and call for research that might help determine whether simulations accomplish what they purport to achieve in terms of participant learning. This article focuses on measuring the effectiveness of using a simulation to affect learning of ERP systems.

In the past few years, ERP systems have had a significant impact on business organizations (Liang, et al., 2007). Consequently, universities and corporate training programs have incorporated some of the commonly used ERP systems (SAP, Oracle, etc.) into curricula and training (Hayen & Andrea, 2003; Antonucci et al., 2004). This is mainly a result of the ever-increasing company use of ERP and enterprise systems as a major component of the business. The systems are large commercial software packages that enable the integration of transaction-oriented data and business processes throughout an organization (Brehm et al., 2000). ERP systems were developed to replace functional information systems, which typically operate in silos in an organization and generate inefficiencies and inconsistencies due to their lack of integration. They offer opportunities for a wealth of learning about integration and functionality, and their competitive information that is commonplace in today's global companies. It should be

noted, however, that the incorporation and use of these large scale systems in classes and training programs is both difficult and challenging.

In this article, we present and compare the learning results using objective measures to assess user knowledge to the results of self-assessed perceptions of learning in the context of an Enterprise Resource Planning (ERP) business simulation game. The comparisons indicate that learning did occur as measured by both objective measures and self-assessed perceptions of learning; moreover, the objective measures were not significantly different from the self-assessed perceptions of learning. These results complement Anderson and Lawton's (2009) article by addressing the assessment of cognitive learning in business simulations and a means to determine whether simulations accomplish what they purport to achieve in terms of participant learning.

ERP/IT Training and Knowledge

User training is considered a cornerstone of change management and a key factor for any successful IT implementation (Compeau, et al., 1995; Nelson & Cheney, 1987). Deficient and inefficient training inhibits ownership of the technology and limits the full realization of benefits from these new investments (Nelson et al., 1995). User training is often provided by means of classroom presentation, accompanied by "hands on" exercises with fictitious problems (Yi & Davis, 2003) for practice. The common methods used in the classroom generally involve "hands on" use of ERP system modules in exercises to solve independent and often unrelated business process problems - production, inventory, sales, customer orders, etc. Users in these training programs are engaged in an individual cognitive process that generally leads to the development of

technical competency related to the application; this technical knowledge acquisition is generally not sufficient to train productive IS users (Kang & Santhanam, 2003). They suggest that users must be trained on the "business context" in which these applications are used as well as the collaborative interdependencies underlying these systems; they must understand these interdependences.

Seethamraju (2007) studied students ' perceived knowledge gain after incorporating ERP SAP instructional strategies into a business curriculum (readings, examples, exercises and classroom lectures). His analysis revealed that students perceived that they had a significantly higher level of knowledge gain such as implementation and SAP software skills. Basselier, et al. (2001) elicit the components of both explicit and tacit knowledge in order for a manager to be competent in IT. They define IT competency as a set of IT-related explicit and tacit knowledge that enables one to act proactively in order to successfully perform their job. Explicit IT Knowledge covers knowledge of technologies, applications, system development, management of IT, and access to IT knowledge. Tacit Knowledge includes the experience of the manager (personal use of computers, IT project experience, and management of IT) as well as their cognition (process adaptation and vision about the role of IT in the organization).

Other researchers have focused on the organizational level; Stratman and Roth (2002) define and operationalize constructs underlying ERP competence of an organization (a portfolio of managerial, technical and organizational skills and expertise). They find evidence of a relationship between ERP competence at the organizational level and improved business performance. While this measure is also self-assessed and targets the measurement of ERP competency at the organizational level, it encompasses

dimensions relevant to measuring the knowledge of the IT workforce such as business and IT skills in addition to IT training.

More recent studies have focused on a knowledge aspect central to the notion of the integration of systems. Building on Sein et al. (1996), Kang and Santhanam (2003) suggested the consideration of IT knowledge as a continuum. Focusing on collaborative applications, such as an ERP system, they suggest that a productive IT user should have knowledge of the following dimensions: (1) technical IT knowledge related to the commands and tools embedded in the IS applications, (2) business IT knowledge related to the contextual knowledge covered by the use of the IS application, and (3) collaborative IT knowledge related to the understanding of tasks interdependent with those of other users of the IS application. The later dimension truly differentiates this particular framework from other previous contributions and seems to more appropriately fit the context of an enterprise system.

Much of the current research has relied on attitudes, perceptions, and self reports to assess learning; the present study attempts to present objective measures and compares results to traditional affective measures.

ERP Simulation - Facilitating Learning

Faculty at HEC Montréal developed a business simulation game with some unique features (Léger, 2006; Léger, et al., 2007); the HEC Montréal ERP simulation game uses a real-time simulation approach; the simulator, ERPSIM, reacts in real time to each teams' decisions. The interface between the simulator and the participants is SAP, a real ERP system. Simulation participants are placed in a situation in which they have to

"manage and run their business" using SAP to implement business transactions similar to those in world's largest companies.

The ERP Simulation Game is a business game played by teams of three to five players. In the original game, each team runs a make-to-stock Muesli cereal company and competes with other teams. Teams have to plan, procure raw materials, schedule production and market Muesli boxes. To perform these tasks, participants must be able to use an ERP system, SAP, to support decision making. The ERP simulation software automates a series of transactions which create a realistic business environment in which teams compete. To be successful in the game, participants must not only be able to interact with SAP, but must also be able to collaboration as a team, understand the business environment, and implement the proper business decisions.

By accessing standard SAP managerial accounting reports, participants analyze transactional data for business decisions and for the profitability of their operations. In the simulation game, participants (students, employees, or managers) must make business decisions and perform complex tasks with the objective of maximizing profits and/or market share of their (virtual) company. In pursuing these goals, the participants have the support of powerful integrated IT system processes within SAP.

Traditional training methods include examples, lecture, and lab exercises. The ERP simulation game provides a unique, alternative way to enhance business process learning and train users in the effective use of ERP systems. ERP simulation offers a hands-on method that facilitates learning of the concepts underlying enterprise systems, helps managers experience the benefits of enterprise integration firsthand, and allows participants to develop decision making skills. As a training tool, it helps middle

management learn how to become more productive by using ERP software. In addition, the simulation game can be used to enhance the decision making skills of business managers and executives by making effective use of SAP's integrated system processes.

The ERP Simulation (ERPSIM Game) and the Participant's guide to the simulation (Léger et al., 2007) are now used by more than 100 faculty members and in more than 70 universities worldwide. As of June 2010, more than 3,000 students annually have played the game across the SAP University Alliance. Professionals at many Fortune 1000 organizations are now introduced to SAP by playing the simulation game.

Self-assessed Measures of IT Knowledge

The question "*what IT knowledge is needed to effectively and efficiently use an ERP system?*" has been of great interest to IT researchers. Over the last decades, several researchers have developed self-assessed constructs in an attempt to measure IT knowledge (Yoon 2008; Basselier et al., 2001; Cronan, et al, 2009a; Cronan, et al., 2009b; and Marcolin, et al., 2000, among others).

The individual self-assessed instrument items used in this study are summarized into learning factors in addition to a several measures of attitude. The items were initially developed (and subsequently expanded) based on items used by Seethamraju (2007) as well as Kang and Santhanam's (2003) categories of knowledge components of their proposed model of collaborative application training. The ERP learning factors with their corresponding items are presented in the Appendix 1. Based on exploratory factor analysis, sixteen items are used to measure enterprise systems management knowledge, business process knowledge, and SAP transactions skills. *Enterprise Systems (ES) Management Knowledge* is defined as the extent to which an individual understands the

impact of an ERP (and the information it provides integrated) on the organization as a whole - including impacts on organizational structures and responsibilities, business processes, reporting, control (or insurance) and decision making. ES reflects the individual's knowledge of how enterprise management utilizes an ERP and how the use of ERP affects the enterprise.

Business Process Knowledge is the extent to which an individual has a general understanding of business terminology, key operations processes, and their inter-relatedness. Business process knowledge includes understanding the delineation of key business activities within and between functional areas such as financial accounting, procurement, manufacturing and sales. *SAP Transaction Skills* represents the extent to which an individual has the information systems user skills required to utilize the SAP application to perform transactions supporting business operations as well as setup and understand the associated master data. Factor analysis (with varimax rotation) was used to validate the learning factors and that Cronbach's alpha was indicative that the scales were reliable.

Objective Measures of IT Knowledge

To objectively measure IT knowledge, a collection of objective questions measuring IT competency and IT knowledge of an individual ERP/SAP system user was developed. Initially, sixty (60) objective questions were developed by a panel of experts to cover the three dimensions proposed by Kang and Satharman (2003). Questions were developed to assess one of the following three dimensions: (1) the *ERP application* (command-based, tool procedural and tool conceptual); (2) the *business context* in which the ERP application is used (business-procedural and business-motivational); and (3) the

collaborative tasks enabled by the ERP application (task interdependencies and collaborative problem solving approach). Building on the call from Anderson and Lawton (2009) to assess higher levels of learning domains, the questions were developed to target different levels of learning objective for the revised taxonomy of learning objectives (Bloom's taxonomy revised) (Krathwohl, 2002)—basic knowledge, comprehension, and analyze. Question objectives vary from being able to recognize information (basic knowledge), to process information by restating in their own terms (comprehension), to apply knowledge to a problem (application), to identify constraints in a problem (analysis). Due to the use of multiple answers to test knowledge, it was not possible to measure knowledge at the synthesis and evaluation level (objective questions used in this research can be obtained by contacting the authors of this article).

Experts, faculty members of the SAP University Alliance who are teaching ERP systems, were asked to answer the questions. In addition to correctly answering the specific question, they were asked to evaluate the extent to which each question measured the participant's knowledge with respect to ERP application, business context in which the ERP application is used, and collaborative tasks enabled by the ERP application. Finally, to assess whether these questions were targeting various levels of learning objective, experts were asked to evaluate the level of complexity of each questions.

Questions submitted to the experts pertained to the use of SAP in the context of the ERP simulation game previously described. It should be noted that the experts invited to respond to the survey all have been trained to use the ERPSIM software and have previously used the software to run the ERP simulation game in their respective classes. As a result, the simulation, the technology used to play it, and the business

context of the business game offer a common point of reference for all experts. Questions submitted to the experts for their responses refer to the knowledge required by players in the game.

Of the one hundred (100) faculty contacted, fifty nine (59) answered at least one of the sixty (60) questions. Each question was answered by at least twenty (20) experts. Questions that were correctly answered by at least 60% of the experts were retained for analysis in this study; otherwise, the question was considered to be ambiguous and was removed from the analysis. Thirty (30) questions were retained for subsequent analysis in this research.

Comparing Self-assessed Measures and Objective Measures of Learning

One hundred twenty (120) game participants were used in the study. Participants were organized into forty (40) teams, three (3) participants per team. Each team played four (4) short games of approximately twenty (20) minutes each – the game used for this study was a shorter version of the ERP simulation game developed at HEC Montreal (Léger et al, 2006). Before the initial game was played, in between each game, and after the last game played, participants had to individually answer six (6) objective questions. All game participants answered individually – in random order – all thirty (30) of the objective questions used.

Each team member had a specific self-assigned role (planner, scheduler, or seller) with specific tasks to accomplish within the team. To be successful, teams had to manage a make-to-stock manufacturing company, producing up to three (3) products and competed against robot teams which were managed by the simulator (to ensure standardization of the game for each team). The *planner* was responsible for planning,

running the MRP and purchasing the raw materials. The *scheduler* was responsible for releasing the production order. Finally the *seller* had to establish a price for each of the three products based on available stock as well as market supply and demand. Each team member had some impact on the profitability of their firm in the context of the ERPSIM simulation game. Incentives for each team were to maximize total company profits, primarily, and to participate in the ERPSIM international competition (the eight best teams were invited to participant in the grand finale).

Learning Measures -- Analysis and Results

The objective of this article is to present and compare the learning results using objective measures to assess user knowledge to those of self-assessed perceptions of learning in the context of an Enterprise Resource Planning (ERP) business simulation game. To compare learning measures, we present summary scores for learning and the degree of correlation between self-assessed measures and the objective measures of knowledge. In effect, we address whether participants' perception of learning significantly relates to its ability to objectively answer about ERP systems.

ERP simulation participant learning measures (previously described) were administered during and following participation in the simulation and then compared. A sample of 120 participants was used in the study. Table 1 presents the summary statistics for the self-assessed measures of knowledge. Results of the self-assessed measures indicate that the average self-assessed knowledge measures after participation in the simulation game are 5.25, 5.13, and 5.23 for ES management knowledge, ES business knowledge, and ERP transactions skills, respectively (using a seven point Likert

scale; where 7 is the highest level of self-assessed learning). Participants indicated that they learned from the simulation experience.

Table 1 Descriptive statistics – Self-Assessed Knowledge

Self Assessed Knowledge **measures**	**Mean**	**Std. Dev.**	**Cronbach Alpha**
Perceived Enterprise Systems Management Knowledge	5.25	1.10	0.912
Perceived Business Process Knowledge	5.13	1.08	0.952
Perceived ERP Transaction Skills	5.23	1.02	0.901

(using a seven point Likert scale (1 – 7); where 7 is the highest level of self-assessed learning)

Table 2 presents the summary statistics for the objective measures of knowledge following participation in the simulation game. Knowledge Overall measures the success rate on all 30 questions. On average, participants were able to correctly answer 54% of the questions. The objective knowledge questions were initially developed to represent the three dimensions of the knowledge constructs proposed by Kang and Satharman (2003). Since we were not able to discriminate between the business and collaboration dimension (Léger et al., 2010), a single average was calculated for these combined dimensions. It appears that the participants scored higher in business and collaboration knowledge (56%) than on the ERP knowledge (53%).

Moreover, the twenty (20) questions below the median where considered *easy* while the 10 other *complex* based on ratings by experts regarding the level of complexity. Stated differently, learning objectives lower on the revised Bloom taxonomy are measured using the *easy* questions, while the other learning objectives (application and

analysis levels) are measured by the *complex* questions. On average, participants have a significantly higher rate answering easy questions (58%) compared to complex questions (47%).

Table 2 Descriptive statistics – Objective Measures of Knowledge

Objective measures	Mean*	Std. Deviation
Objective Knowledge Overall (30 questions)	0.54	0.17
Objective Knowledge ERP (15 questions)	0.53	0.17
Objective Knowledge Business/Collaboration (15 questions)	0.56	0.19
Objective Knowledge - Easy (20 questions)	0.58	0.19
Objective Knowledge - Complex (10 questions)	0.47	0.18

*Percent Correct

Table 3 presents the correlation results when post simulation participation learning measures, self-assessed and objective measures, are compared. Student GPA was also included in the analysis. The correlation analysis results indicate significant correlation between the objective measures and the self-assessed measures. While all measures were significantly correlated, the Knowledge Easy score had the strongest of all correlation with the self-assessed measures (.43, .45, and .47) and complex knowledge had the smallest correlations (.23, .22, and .27). A Steiger test was used to compare the correlation coefficients between the different objective knowledge measures and each of the self-assessed constructs; Knowledge-Complex correlation coefficient is significantly lower than all than all other correlations ($p < 0.01$). Moreover, business knowledge correlation coefficient is higher with Knowledge-Complex yet lower with Knowledge-

Easy. Finally, it should be noted that the GPA of the participants is not significantly correlated with the self-assessed measures or the objective measures.

Table 3 Pearson Correlation between Self-Assessed and Objective Variables

	Self-Assessed Measures					
	Enterprise Systems (ES) Management Knowledge		Business Process Knowledge		ERP Transaction Skills	
Objective Knowledge	**Corr.**	**Sig[1]**	**Corr.**	**Sig[1]**	**Corr.**	**Sig[1]**
Objective knowledge Overall (30 questions)	0.41	**	0.43	**	0.46	**
Objective knowledge ERP (15 questions)	0.38	**	0.40	**	0.41	**
Objective knowledge Business/collaboration (15 questions)	0.37	**	0.39	**	0.42	**
Objective knowledge - Easy (20 questions)	0.43	**	0.45	**	0.47	**
Objective knowledge - Complex (10 questions)	0.23	**	0.22	**	0.27	**
Converted GPA	0.03	Ns	0.09	Ns	0.11	Ns

[1] Bilateral test for Pearson correlation (** $p < 0.05$)

Conclusions and Directions

The objective of this article was to present and compare two different methods to assess knowledge acquired in a simulation game—self-assessed knowledge and objectively measured knowledge. As reported by Anderson and Lawton (2009), very few studies have used objective measure to assess the effectiveness of simulation based learning. This article presents the learning results for participants in an ERP simulation game assessed by objective measures and by self–assessed measures. Learning measures are presented and compared. The results indicate significant correlation between the objective measures and the self-assessed measures of knowledge. By testing the correlation between these two measures (self-assessed and objective), another objective was to access the validity of using perceived (self-assessed) measures as well as provide effective objective measures of learning in this ERP simulation context.

In general, it appears that a significant association prevails between the perception of knowledge of the participants (self-assessed measures) and their ability to answer objective knowledge questions about ERP system. The correlation is significantly stronger for lower learning levels (revised Bloom's taxonomy) which should be expected. Moreover, some participants appear to overestimate their actual knowledge for higher levels of learning. Potvin et al. (2010) explored the impact of participants' confidence about their knowledge in problem-based approaches. As suggested by their results, further research should explore the role of overconfidence of the participants regarding their misperception of knowledge in the context of business simulation.

Further research is needed regarding learning gained from simulation nased problems (both objective measures and self-assessed). More research in this area should not only make available reliable guidelines for developing and testing objective measures of learning specific to the simulation learning objectives, but attempt to discern what aspects of simulation based leaning is more effective.

Some caution is needed when interpreting and using the results. Because this study was done in a competition context, it is possible that students more interested in active learning were attracted, which could bias the results. In addition, objective knowledge was tested with multiple answer questions only; Anderson and Lawton (2009) suggest that triangulating higher level learning with different assessment mode could help in getting a more valid measure of synthesis and evaluation learning objectives.

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Appendix 1: ERP Simulation Self-Assessed Instrument Items

Enterprise Systems (ES) Management Knowledge - *the extent to which an individual understands the impact of an ERP (and the integrated information it provides) on the organization as a whole – including impacts on organizational structures and responsibilities, business processes, reporting, control (or assurance) and decision making. ES reflects the individual's knowledge of how enterprise management utilizes an ERP and how the use of ERP affects the enterprise. (These items were measured using a 7-point Likert scale ranging from 1 – very low to 7 – very high)*

- Ability to analyze the impact of integrated information on managerial decision making
- Ability to analyze the impact of individual employee actions on the operations of other functional areas
- Ability to understand the role and complexity of technology in enterprise system software solutions

Business Process Knowledge - *the extent to which an individual has a general understanding of business terminology, key operations processes and their inter-relatedness. Business process knowledge includes understanding the delineation of key business activities within and between functional areas such as financial accounting, procurement, manufacturing and sales. (These items were measured using a 7-point Likert scale ranging from 1 – very low to 7 – very high)*

- Knowledge of business terminology in Sales and Distribution (such as Sales order, discounts, freight, transfer goods, good issues etc.)
- Knowledge of business terminology in Procurement process (such as Purchase Order, invoice verification, goods receipt, material account, etc.)
- Knowledge of Production Management Business Processes and Activities
- Knowledge of the importance of the integrated nature of the business processes
- Knowledge of the interrelationships and interdependencies between various functions (such as accounting, marketing, productions, etc.)
- Knowledge of Procurement Business Processes and Activities
- Knowledge of Sales and Distribution Business Processes and Activities
- Knowledge of Financial Accounting Business Processes and Activities

SAP Transaction Skills – *the extent to which an individual has the information systems user skills required to utilize the SAP application to perform transactions supporting business operations as well as setup and understand the associated master data. (These items were measured using a 7-point Likert scale ranging from 1 – very low to 7 – very high)*

- Ability to accomplish transactions to procure inventory in SAP
- Ability to accomplish transactions to set (and change) prices and sell products in SAP
- Ability to accomplish transactions to collect from customers
- Ability to accomplish transactions to produce/manufacture goods (set up Production) in SAP

- Ability to accomplish transactions to pay for purchases (accounts payable in SAP)

Appendix 2: ERP Simulation Objective Measures

The objective measures used can be obtained from the authors by request